RESISTOR AND COLOR CODE

Resistors are very important components and are frequently used in electronic circuits. They control the amount of current in a circuit. A resistor can control current because it has a specified amount of resistance.

All resistors have specifications that must be met by the manufacturer before they will be accepted for use by both the military or civilian user. These standards provide reliable facts regarding identification by coding, size and shape.

The composition resistor's construction is a chemical composition which determines its ohmic value. The most common resistor has as it's principle resistive ingredient CARBON.

Lets begin by looking at some resistor characteristics

In the manufacturing process of a carbon resistor, fillers or binders are added to the carbon to obtain various resistance values. Examples of the fillers are: CLAY, BAKELITE, RUBBER and TALC. These fillers are called DOPING agents.

Carbon resistors are most commonly used because they are easy to manufacture, inexpensive and have a tolerance that make them adequate to use in most electrical and electronic applications.

Composition resistors have a resistance range from .15 ohm to 10 mega ohms with a tolerance between +/- 5 to +/- 20 % and a wattage range from 1/8 to 5 watts.

The prime disadvantage of the carbon resistor is that it has a tendency to change value as it ages. Another disadvantage is that it will change value with heat. A carbon resistor is also limited in power handling capability.

Film resistor construction is performed by depositing thin layers of resistive material on an insulated core. This process can be used to make up low resistance values.

Carbon film resistors are smaller in actual size than the carbon composition resistors.

Carbon film resistors have a greater hear dissipation capability than the carbon composition resistors.

Carbon film resistors have resistance ranges from 1 ohm to 200 mega ohms with a tolerance range of +/- 5 to +/- 10 % and a wattage range from 1/10 to 100 watts.

Metal film resistors have a resistance range from .27 ohm to 100 mega ohms with a tolerance range of +/- .01 to +/- 20% and a wattage range of 1/20 to 20 watts.

An advantage of the carbon film resistor is the physical size compared to the power handling capabilities.

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Carbon and metal film resistors use a 5 band color code to dentify their resistance value.

Wirewound resistor construction is an element of nickel-chromin or copper-nickel alloy wound around a tubular ceramic material.

The cases are usually rectangular or circular and are made of ceramic material. The preferred wirewound resistor is the metal heat-sink type.

The wirewound resistor is easy to recognize because the resistance values and wattage are often printed on the case.

Wirewound resistors can be color coded using the standard color code. To inform the user that the resistor is wirewound, the first color band will be two times as wide as all the other bands.

One use of a wirewound resistor may be as a "power" resistor; which has a resistance range from .1 ohm to 1 mega ohms, a tolerance range of +/- 1 to +/- 10% and a wattage range of 1 to 1500 watts.

Another use of a wirewound resistor is as a "precision" resistor; which has a resistance range from .001 ohm to 60 mega ohms, a tolerance range of +/- .001 to +/- 1% and a wattage range of 1/25 to 250 watts.

An advantage of the wirewound resistor is that the ohmic values can be very precise and have very little tolerance values.

One disadvantage of the wirewound resistor is that it takes a large amount of wire to manufacture a resistor of high ohmic value thereby increasing the cost of the resistor.

The resistor's physical size and manufacturing has nothing to do with the resistance value. A resistor that is large in physical size may have the same resistance value as a resistor with a much smaller physical size.

The physical size of a resistor suggest it's current carrying capabilities. When current passes through a resistor heat is developed within the resistor

The resistor must dissipate heat into the surrounding air. If the heat is NOT dissipated, the resistance value may change or the resistor may open.

Heat dissipation is dependent onn the surface area of the resistor. This heat or power dissipation is measured in WATTS

A low wattage rating means the resistor is capable of handling small amounts of power safely.

A high wattage rating means the resistor is capable of handling a amounts of power sa

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Some of the common wattage ratings are: 1/8 watt, 1/4 watt, 1/2 watt, 1 watt and 2 watts. The higher the wattage rating the larger the physical size.

When replacing a resistor in a circuit and the wattage is unknown, you can simply calculate wattage the circuit. To do this use the following formulas: (See FIGURE 3) (SLIDE EP07AL-S03).

FORMULAS FOR WATTAGE (POWER)

$$P = I^2R \qquad P = \frac{E^2}{R} \qquad P = EI$$

P = POWER
I = CURRENT
E = VOLTAGE
R = RESISTANCE

FIGURE 3, (SLIDE EP07AL-S03)

Once the wattage has been calculated, you should DOUBLE the answer to be on the safe side.

There are two basic types of resistors; FIXED AND VARIABLE, as shown schematically in FIGURE 4. (See FIGURE 4) (SLIDE EP07AL-S04)

RESISTOR SCHEMATICS

FIXED **VARIABLE**

RESISTOR AND COLOR CODE

The fixed resistor may be understood to have the following characteristics:

1. A set value which cannot be changed.

2. It may be wirewound or caron composition.

3. It may be a tapped resistor. This type of resistor has more than one fixed resistance value.

4. It may be a sliding contact resistor which is used as a fixed tapped resistor. This resistor has a collar which is normally adjusted to a desired position and then kept at that desired value.

The schematic symbol for the fixed resistor is:

(See FIGURE 5) (SLIDE EP07AL-S05)

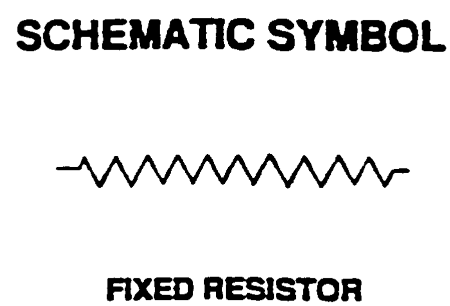

FIGURE 5, (SLIDE EP07AL-S05)

Variable resistors are either tubular or circular in form and are constructed with one permanently connected contact and one moveable contact.

The schematic symbol for the variable resistor is:

(See FIGURE 6) (SLIDE EP07AL-S06)

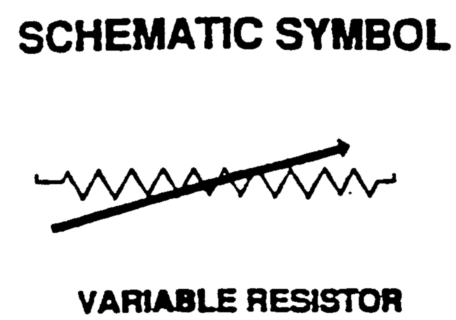

FIGURE 6, (EP07AL-S06)

The variable resistor may be understood to have the following characteristics:

1. The resistance can be changed by an adjustable control

2. It may be called a RHEOSTAT or a POTENTIOMETER, commonly referred to as a "POT"

The schematic symbols for these resistors are: (See FIGURE 7) (SLIDE EP07AL-S07)

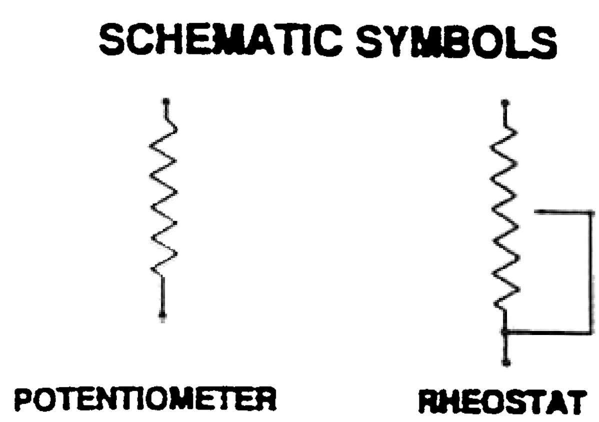

FIGURE 7, (SLIDE EP07AL-S07)

The rheostat is used in the circuit to control current. It changes the circuit's total resistance. It only uses two terminals

RESISTOR AND COLOR CODE

The potentiometer is used in the circuit to control voltage. It does NOT change the circuit's total resistance. It uses three terminals.

SUMMARIZE: Resistors fall into two major groups, FIXED and VARIABLE. They may be either wirewound or carbon composition. The carbon composition is the most common used. The carbon film is being used more and more because of it's size and it's capability to dissipate heat better. If you need to adjust the current flow or voltage within a circuit, the variable resistors will be used. The two most common variable resistors are the rheostat and the potentiometer.

QUESTION: 1. What are the two major classes of resistors?

QUESTION: 2. A rheostat is what type of resistor?

QUESTION: 3. What type of resistor has only one value?

QUESTION: 4. What are the types of wirewound resistors?

FIGURE 8 (SLIDE EP07AL-S08)

ANSWER: 1. Fixed and variable.

ANSWER 2. Variable.

ANSWER 3. Fixed

ANSWER 4. Power and precision.

FIGURE 9 (SLIDE EP07AL-S09)

You can tell how much resistance a resistor has by reading the color hands painted on it, each color stands for a number. Colors are used most often because inside the equipment you can see colors better than numbers, especially on small resistors.

Resistors are not perfect. The true ohmic value of a resistor may vary slightly from the basic ohms rating given by its color bands or numbered value. This variation is actually an allowed error called TOLERANCE. You can tell how much a resistor value is allowed to vary by reading the tolerance band or letter.

You have calculated resistance, using Ohms Law, now it is time to learn how to read the value of a resistor from its color-coded markings.

Although some resistors have their resistance printed in numbers and letters, this is not very practical in most cases. The printed value might be out of sight or under the resistor where you couldn't see it. The resistors are so small, that printing numbers which are easy to read would also be difficult. Heat and weathering in some circuits or mechanical friction, could make the small numbers hard to read. However, a colored line, going completely around the resistor, would be readable in an position. Also it would be unlikely that all parts of the circle would be discolored by heat or weathering, or subject to rubbing on other components.

There are 12 colors used to identify resistance values and each color has a numerical value assigned to it.

Figure 10 shows 12 of the basic colors used

Black	=	0 Bad	Tolerance bands		
Brown	=	1 Booze	Gold	=	+/- 5%
Red	=	2 Rots	Silver	=	+/- 10%
Orange	=	3 Our	No color	=	+/- 20%
Yellow	=	4 Young			
Green	=	5 Guts	Multiplier Band		
Blue	=	6 But	Gold	=	.1
Violet	=	7 Vodka	Silver		
Gray	=	8 Gets			
White	=	9 Worse			

FIGURE 10 (SLIDE EP07AL-S10)

SUMMARIZE: The colors painted on resistors represent a number and these numbers are zero through nine. These are called the basic value. The easy way to remember these combinations of numbers and colors is through a memory agent.

QUESTION: 1. What number does green represent?

QUESTION: 2. What number is represented by brown?

QUESTION: 3. What number corresponds to blue?

QUES"ION: 4. What number is white equal to?

FIGURE 11 (SLIDE EP07AL-S11)

RESISTOR AND COLOR

ANSWER: 1. 5

ANSWER: 2. 1

ANSWER: 3. 6

ANSWER: 4. 9

FIGURE 12 (SLIDE EP07AL-S12)

First Color Code Band:

(See FIGURE 13) (SLIDE EP07AL-S13)

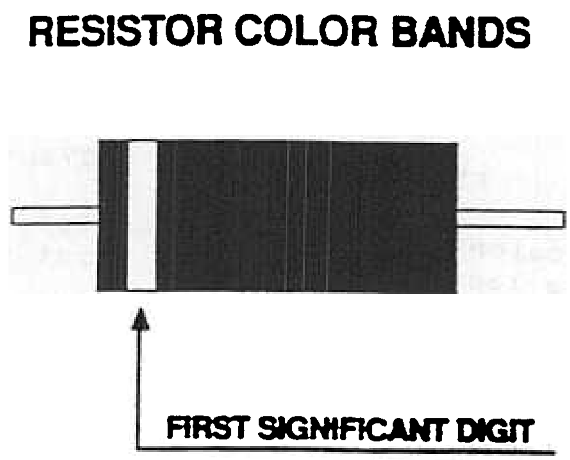

FIGURE 13, (SLIDE EP07AL-S13)

The band near the end of the resistor will be the first color band

It will be followed by at least 2 other color bands in close proximity.

The first band will never be BLACK, GOLD or SILVER.

The first color band will represent the FIRST SIGNIFICANT DIGIT in the resistance value of the resistor.

This band may be twice as wide as the other bands, this indicates that the resistor is a wirewound resistor.

RESISTOR AND COLOR CODE

Second Color Code Band:

(See FIGURE 14 (SLIDE EP07AL-S14)

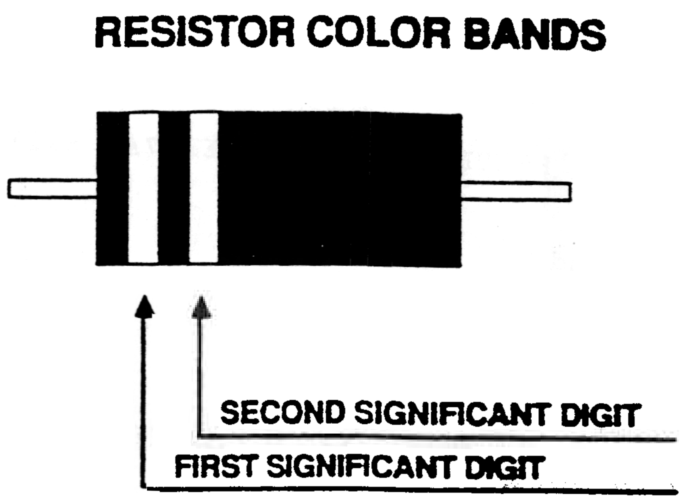

FIGURE 14, (SLIDE EP07AL-S14)

The second color code band is the 2nd SIGNIFICANT DIGIT of the color code and is located next to the first color code band.

It will bever be GOLD or SILVER

Third Color Code Band:

(See FIGURE 15) (SLIDE EP07AL-S15)

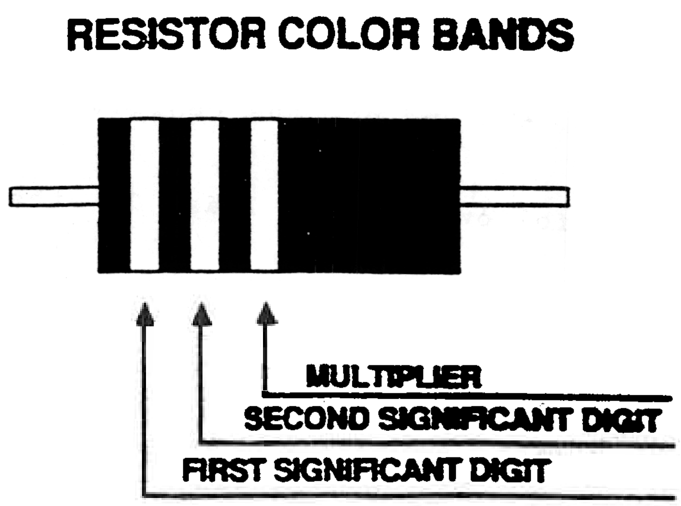

FIGURE 15, (SLIDE EP07AL-S15)

The third color code band has two general purposes: (Which ONLY applies to the carbon composition resistors)

The first purpose is to tell how many zeros to add to the first two numbers that was established by the first two color codes. The color used defining the number of zeros to add are black through white or no zero to nine zeros.

The second purpose is to define resistor values of less than 10 ohms and less than one ohm.

If GOLD and SILVER appears in the 3rd band, then this band becomes a multiplier band.

If gold appears in the third band, this indicates that the total resistance offered by the resistor is less than 10 ohms. Using the first two significant digits simply multiply .1, as shown in Figure 12.

MULTIPLIER BAND "GOLD"

EXAMPLE

FIRST DIGIT = 2 **SECOND DIGIT = 5**

THIRD GOLD = **25**
x .1
2.5 OHMS

FIGURE 16 (SLIDE EP07AL-S16)

If silver appears in the third band, this indicates that the total resistance offered by this resistor is less than 1 ohm. Simply multiply the first two digits by .01, as shown in Figure 13.

RESISTOR AND COLOR CODE

If no color band is in the fourth space, the tolerance will be +/- 20%.

If a black band appears as the fourth band, the tolerance of the resistor will be +/- 20%.

If a gold band appears as the fourth band, the tolerance of the resistor will be +/- 5%.

If a silver band appears as the fourth band, the tolerance of the resistor will be +/- 10%.

If green appears as the fourth band a guaranteed minimum value is implied. (GWV).

If any color appears as the fourth band it will represent a tolerance value equaling its numerical value, as shown in FIGURE 15

TOLERANCE COLOR CODE

BLACK	± 20%	VIOLET	± 7%
BROWN	± 1%	GRAY	± 8%
RED	± 2%	WHITE	± 9%
ORANGE	± 3%		
YELLOW	± 4%	GREEN GUARANTEED MINIMUM VALUE	
BLUE	± 6%		

FIGURE 19 (SLIDE EP07AL-S19)

RESISTOR TOLERANCE EXAMPLES

RESISTOR ACCEPTABLE	5K OHMS 5,250	GOLD TOLERANCE OR 4,750 OHMS
RESISTOR ACCEPTABLE	5K OHMS 5,500	SILVER TOLERANCE OR 4,500 OHMS
RESISTOR ACCEPTABLE	5K OHMS 6000	NO COLOR TOLERANCE OR 4000 OHMS

FIGURE 20 (SLIDE EP07AL-S20)

NOTE: To find the absolute tolerance amount of a resistor, multiply the basic ohms rating by the tolerance. This will give you the tolerance; now add this to the basic ohmic value. This value is the upper limit. To find the lower limit subtract the tolerance you have calculated from the basic ohmic value

FAILURE RATE

BROWN	M	1%
RED	P	.1%
ORANGE	R	.01%
YELLOW	S	.001%

FIGURE 24 (SLIDE EP07AL-S24)

Second, the type of terminal. This is used for film resistors only and will be white if it is solderable.

Third, test sequence. If green is present it signifies that the resistor was tested after the load cycle test.

Color Bands for Film Resistor. All colors and numerical values are the same as they are for the carbon composition resistors.

The first color band, represents the FIRST SIGNIFICATION DIGIT.

The second color band, represents the SECOND SIGNIFICANT DIGIT.

The third color band, represents the THIRD SIGNIFICANT DIGIT. (See FIGURE 25) (SLIDE EP07AL-S25)

FILM RESISTOR COLOR BANDS

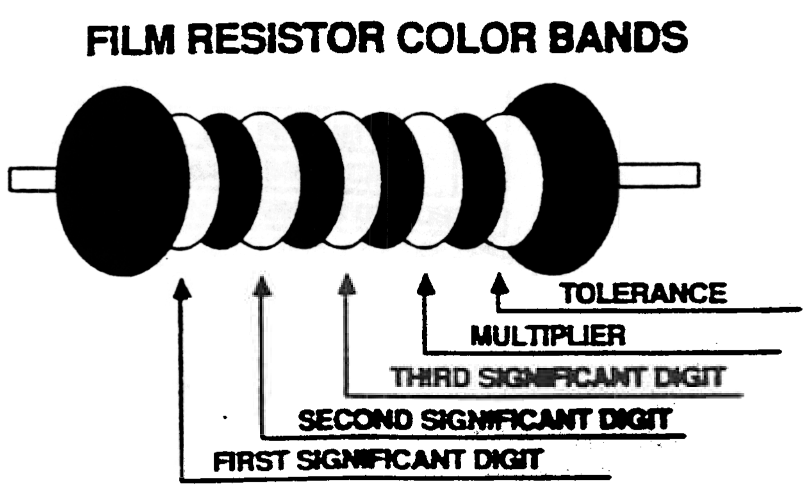

FIGURE 25, (SLIDE EP07AL-S25)

RESISTOR AND COLOR CODE

The fourth color band, represents the number of zeros to be added or the special purpose multipliers.

The fifth color band, represents the tolerance band. This can be one of eight colors, each representing a different percent of tolerance

1.	Silver	=	+/- 10%	5.	Green	=	+/- 5%
2.	Gold	=	+/- 5%	6.	Blue	=	+/-.25%
3.	Brown	=	+/- 1%	7.	Violet	=	+/- .1%
4.	Red	=	+/- 2%	8.	Gray	=	+/-.05%

NOTE: If the fifth color code is white it indicates the leads are solderable.

FIGURE 26 (SLIDE EP07AL-S26)

Notice that the tolerance for film resistors are different from the tolerance of carbon composition resistors.

Film resistor identification using numbers and letters will be as shown in Figure 20:

The first number indicates the FIRST SIGNIFICANT DIGIT. (See FIGURE 27) (SLIDE EP07AL-S27)

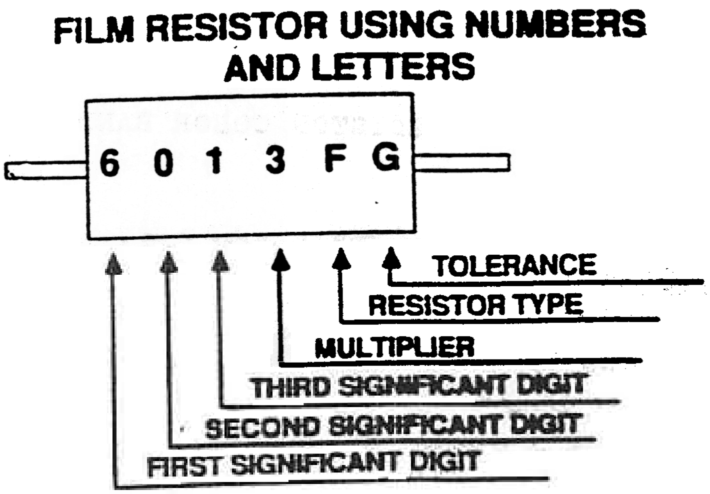

FIGURE 27, (SLIDE EP07AL-S27)

EXAMPLE: 6

The second number indicates the SECOND SIGNIFICANT DIGIT.

EXAMPLE: 0

The third number indicates the THIRD SIGNIFICANT DIGIT

RESISTOR AND COLOR CODE

EXAMPLE: 1

The fourth number indicates the number of zeros to be added to the first three numbers.

EXAMPLE: 3

The first letter shows the physical make up of the resistor.

EXAMPLE: F (indicates FILM resistor)

The second letter indicates the tolerance of the resistor. It can be one of 4 letters.

FILM RESISTOR TOLERANCE
LETTERCODE

M	INDICATED	$\pm$ 20%
K	INDICATES	$\pm$ 10%
J	INDICATES	$\pm$ 5%
G	INDICATES	$\pm$ 2%

FIGURE 28 (SLIDE EP07AL-S28)

SUMMARY:

There are two types of resistors, fixed and variable. Both types, as the resistive element, may be either wirewound or carbon composition. A fixed resistor has only one set value, which may be as low as fraction of an ohm or as high as several million ohm. A variable resistor is called a rheostat. Its resistance may be changed to vary the amount of current in a circuit.

Wirewound resistors usually have a value of resistance stamped on the side. Carbon resistors have color bands to indicate the resistance value and tolerance. Each color stands for a number. Ohmic value of a color coded resistor is read from END-TO-CENTER. The resistor and tolerance color code has a memory aid to help you remember it.